SURFACE ACTIVITY ASSESSMENT USING SIGN TEST

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O R I S E

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OUTLINE

- Current MARSSIM guidance is WRS Test for surface activity assessment
- ISO-7503 approach
- Proposed protocol for surface activity measurements using Sign Test
- Results of computer simulations
- MARSSIM Workgroup discussion

MARSSIM says WRS Test for Surface Activity Measurements

- Current MARSSIM guidance states that WRS Test is used when:

  1) contaminant is present in background, or

  2) gross measurements are performed
- Measurements of surface activity are nearly always gross measurements

Problems with WRS Test for Surface Activity Assessment

- Single survey unit based on contamination potential could potentially be divided into multiple survey units due to the number of surface materials present; thus WRS Test:
  - requires many measurements
  - not consistent with dose modeling for DCGLs
  - not consistent with ISO-7503 approach
  - not possible when subtracting multiple bkgs

Surface Activity Survey Instrumentation

- Gas proportional (3 modes of operation)
  - Alpha-only (using voltage setting)
  - Beta-only (using Mylar thickness)
  - Alpha plus Beta
- GM (measures primarily beta)
- ZnS (alpha measurements)
- Phoswich detectors (alpha and beta)

Conventional Approach to Surface Activity Assessment

- Surface activity in dpm/100 cm[2] is given by:

$$A_S = \frac{R_{S+B} - R_B}{(\varepsilon_{total})(P.A./100)}$$

where:

» R_{S+B} is the gross count rate (cpm)

» R_B is the appropriate background count rate (cpm)

» ε_{total} is the total efficiency (c/dis)– 4π value

- Concern was raised that subtracting background reduced power vs. comparing distributions (WRS)

Uncertainty in Surface Activity Assessment Variables

- Spatial and measurement uncertainty (Poisson) in R_{S+B} and R_B
- Dominant source of uncertainty is total efficiency; driven by variety of surfaces, with varying surface conditions [reason for ISO-7503 approach]
- Note: The spatial variability of surface material backgrounds is relatively small due to uniformity of many materials; not true for soil contaminants

ISO-7503 METHODOLOGY

- Separate total efficiency into instrument and surface efficiency components:

$$A_S = \frac{R_{S+B} - R_B}{(\varepsilon_i)(\varepsilon_S)(W)}$$

- where:
  - ε_i is the instrument efficiency,
  - ε_s is surface efficiency,
  - W is the physical probe area

ISO-7503 METHODOLOGY (cont.)

- Distinguishes between instrument efficiency (ε_i) and source efficiency (ε_s) —conventional total efficiency: (ε_i)(ε_s)
- ε_i is the ratio between the net count rate and 2π surface emission rate (includes absorption in detector window, source-detector geometry)—maximum ε_i is 1.0

ISO-7503 METHODOLOGY (cont.)

- ε_s is the ratio between the number of particles emerging from surface and the total surface activity— ε_s includes self-absorption and backscatter
- ε_s is ideally 0.5 (no self-absorption, no backscatter)–backscatter increases value, self-absorption decreases value

Documents that Specify Similar Surface Activity Calculation

- ISO-7503 (1988) - fundamental reference
- NCRP 112 (1991) ; ASTM E-1893 (1997)
- NUREG/CR-5849 and NUREG-1507
- DOE Environmental Implementation Guide for Radiological Survey Procedures (1997)
- Reg Guide 1.86 and DOE Order 5400.5
- Point: Subtracting background is, and has been, part of many guidance documents

Proposed DQO Approach for Using Sign Test

- State the Problem:
  - Need to demonstrate that the surface activity levels in the building satisfy release criteria
- Identify the Decision:
  - Is the level of residual surface activity in each survey unit in Building 259 below the release criterion?

Proposed DQO Approach for Using Sign Test (cont.)

- Identify Inputs to the Decision:
  - Select appropriate survey instruments and determine efficiencies for contaminants of concern
  - Location of background surface materials
  - Initial classification of areas based scoping and characterization data

Proposed DQO Approach for Using Sign Test (cont.)

- Define the Boundaries of the Study:
  - Divide Building 259 into survey units based on contamination potential and congruity with dose modeling
  - Make gross measurements in each survey unit to determine σ_s (guidance p. 5-26)
  - Make background measurements on each type of surface material encountered in survey unit; average background level and σ_r

Proposed DQO Approach for Using Sign Test (cont.)

- Define the Boundaries of the Study: (cont.)
  - Overall standard deviation for planning the sample size (accounts for bkg subtraction):

$$\sigma_{total} = \sqrt{(\sigma_s)^2 + (\sigma_r)^2}$$

  - For survey units with multiple surface materials, use σ_r that provides the largest value of the overall standard deviation

Proposed DQO Approach for Using Sign Test (cont.)

- Define the Boundaries of the Study: (cont.)
  - The overall standard deviation is used to determine the relative shift, and therefore, N
  - MARSSIM users should be cognizant that more background measurements reduce σ_r, and therefore sample size

Proposed DQO Approach for Using Sign Test (cont.)

- Develop a Decision Rule:
  - Specify the DCGLs for each radionuclide and how multiple radionuclides are handled
  - Decision rule: If the median surface activity level in the survey unit is less than the DCGL, then survey unit satisfies release criterion

Proposed DQO Approach for Using Sign Test (cont.)

- Specify Limits on Decision Errors:
  - State null hypothesis and Type I and II errors
  - Surface activity calculated using ISO-7503 at N random locations; each value is subtracted from DCGL, S+ compared to critical value
- Optimize the Decision for Obtaining Data:
  - Review survey unit selection
  - Review estimate of overall variability

Computer Simulations

- Performed to evaluate the statistical power of the WRS vs. Sign test
- Room consisting of three surface materials, was modeled with realistic contamination from Cs-137 and Co-60
- Background levels from concrete floor, drywall and linoleum were realistic data

Computer Simulations (cont.)

- Median contamination levels were selected at 0.7 DCGLw, 0.9 DCGLw, 1.0 DCGLw and 1.15 DCGLw
- Sample sizes for both tests were calculated
- Comparison was 3 individual WRS tests to one Sign test for the entire room
- Modeled detector response at each point from random draws from two distributions

Computer Simulation Results

- Power of WRS test and Sign test were comparable, with Sign test performing better under several situations
- Subtraction of mean background when using Sign test appears to have no appreciable effect on power
- Bottom line: Power of Sign test is sufficiently large compared to WRS test

Summary - WRS Test for Surface Activity Assessment

- Gross measurements use the WRS Test —which requires a background reference area for each different surface material type
- Impractical: areas divided into survey units based on contamination potential **and** surface type; would result in multiple survey units in a single room
- Problem with ties for alpha measurements

Summary - Sign Test for Surface Activity Assessment

- Survey units are formed based on contamination potential alone
- Calculate surface activity using ISO-7503 guidance—requires appropriate surface material background subtraction
- Use average background based on sufficient number of background measurements for each material type (based on DQOs)

Summary - Sign Test for Surface Activity Assessment (cont.)

- The EMC test for elevated areas is also facilitated by converting measurements to conventional surface activity units for comparison to $DCGL_{EMC}$
- Need to determine when it may be advantageous to use the WRS test
  – For surface activity assessments when MDC is greater than DCGLw